UNIT 5 - RENEWABLES
SECTION 3 - SOLAR ENERGY

Investigation

BUILDING A PARABOLIC-TROUGH COLLECTOR

ADAPTED FROM: "BUILDING A PARABOLIC SOLAR WATER HEATER," *ENERGY IN THE CLASSROOM,* 2005

Background Information

Parabolic-trough collectors use curved mirrors to focus sunlight on a dark-surfaced tube running the length of the trough. A mixture of water and fluids that transfer heat is pumped through the tube. The fluids absorb solar heat and reach temperatures up to 299ºC (570ºF). The hot water is sent to a thermal storage tank, or the steam is directed through a turbine to generate electricity. Parabolic-trough collectors provide hot water and/or electricity for industrial and commercial buildings.

Parabolic-trough collectors use only direct radiation, and even though they use tracking systems to keep them facing the sun, they are most effective where there are good solar resources.

Parabolic-trough collectors are more efficient for large facilities that require hot water around the clock. The also require large areas for installation, yet they offset the need for conventional energy and provide energy savings and environmental benefits.

In this activity you will construct and test a parabolic-trough collector and learn the basics of using solar energy to provide hot water and electricity.

Problem: *(fill in problem):* ____

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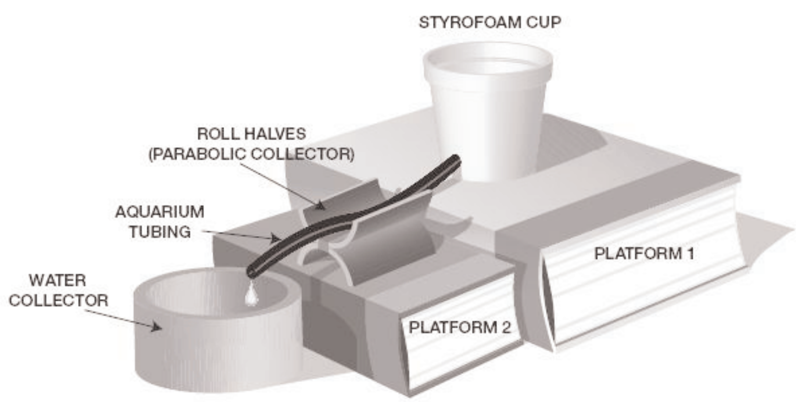
Materials

40 cm of aquarium tubing, painted black
1 cardboard paper towel roll
1 small sheet of aluminum foil
1 pair scissors
1 self-adhesive fastener for binding holed paper
double-sided tape
2 brass brad fasteners
1 gooseneck lamp with 100-200 watt bulb or access to strong, direct sunlight
1 Styrofoam cup
plumber's putty
1 jar or small beaker
goggles
candy thermometer with clip

Procedure

1. Cut the paper towel roll in half lengthwise.
2. Place the roll halves together so their convex sides are touching (back to back)
3. Join the two roll halves together with brass fasteners at both ends of the rolls. (To insert the brass fasteners, you must carefully poke holes in the rolls if this has not been done prior to the lab.)



4. Pull off the paper covering the adhesive side of the self-adhesive fastener. Stick the self-adhesive fastener (adhesive side down) lengthwise in the middle of one of the paper towel roll halves. Add 1-inch strips of double-sided tape on each end of the roll.
5. Bend the 2 prongs of the self-adhesive fastener straight up. Then line the inside of one paper towel roll half with the aluminum foil, shiny side facing up (make slits to slide the foil over the prongs). Smooth the foil as much as possible to reflect the most heat. This is your parabolic collector or heater.
6. Using a pencil, twist and bend each prong to form a closed loop through which the aquarium tubing will slide. Keep the loops as high as possible, off the foil.
7. Slide the black aquarium tubing through the two loops, leaving equal amounts of tubing on each end of your parabolic collector.
8. Poke a small hole in the side of the Styrofoam cup (in the lower side about one-fourth inch

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from the bottom of the cup). (Note: The hole should allow the aquarium tubing to fit snugly through it. Do not make the hole too big.) A pencil or other object can be used for this purpose.

9. Insert one end of the aquarium tubing into the hole in the side of the cup (should be a tight fit). Seal the hole with a small amount of plumber's putty.
10. Place the parabolic collector on a raised object such as a book.
11. Place the cup on an object raised approximately 1/2 inch higher than the collector, such as two books (or one thick book). The cup now is on one level, and the parabolic collector is a half step lower than the cup.
12. Place a water collector (a small jar or beaker) on the tabletop and place the other end of the aquarium tube in it. The top of the water collector should be approximately even with the platform that the parabolic collector is placed on. There should be three stairs or levels. The cup is the highest, the parabolic solar collector is second highest and the jar or beaker is on the lowest level.
13. Using the set-up from your construction, place the parabolic water heater (collector) so that the concave, shiny, aluminum covered side faces the light from the goose-necked lamp at a distance of 3 cm (strong direct sunlight can be used, but may take longer).
12. Measure 100 ml of water in a beaker or graduated cylinder. Record the temperature of the water in the beaker or cylinder.
13. Add the 100 ml of water to the Styrofoam cup, which is standing on the top level of your set-up.
14. Immediately raise or lower the tubing, so that the water drips through the black tubing of the parabolic shiny collector at the slowest rate possible.
15. Record the temperature of the collected water in the jar or beaker during the collection process. Record the temperature every 30 seconds. Mark the reading when all of the water has flowed through the collector and no more is left in the Styrofoam cup.
16. Keep recording the temperature readings after all of the water has flowed through the solar collector for 2 - 3 minutes more.
17. Create a graph to indicate the temperature readings taken every 30 seconds. Indicate the time when all the water has flowed through the tubing.
18. Interpret the results of your graph to include what happens to the temperature during the flow of water and what happens after it has stopped flowing.

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Observations

Water Temperature Readings

Time	Temperature	Notes

Conclusion

1. What was the temperature of the water when you started? ______________________________

2. What was the highest temperature reached? ____

3. How long did the water stay at the highest temperature? ________________________________

4. How could you keep the water at the highest temperature longer?

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5. Why is a parabolic curve used as a collector? ____

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6. Why is the tubing painted black? ____

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7. How can you design a better collector? ______________________________

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Application

1. What are some limitations of a solar water heater? ______________________________

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2. What arguments can you make for using solar energy to heat water? ______________________________

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3. Data was gathered from a facility using a parabolic-trough solar water heater. The facility offset 89,000 kWh of electricity consumption per month at a savings of $0.065/kWh. What was their annual savings? ______________________________

4. The initial cost to install the system in question #3 was $649,000. Using simple payback, how long would it take to recover the installation cost? ______________________________

Going further

5. If traditional electricity production of 1MWh releases 1,109 lbs. of CO_2 and a parabolic-trough solar water heating system offsets an average annual consumption of 1,000 MWh of electricity, how much less CO_2 would be released into the atmosphere? ______________________________